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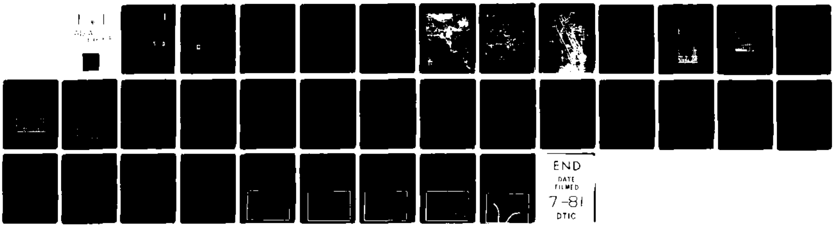

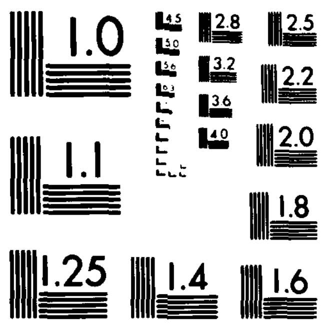

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TERMINAL FORECAST REFERENCE NOTEBOOK

FOR

HELLENIKON AB, GREECE

APPROVED FOR PUBLIC RELEASE:
DISTRIBUTION UNLIMITED

PUBLISHED BY:
OPERATING LOCATION C
31ST WEATHER SQUADRON
2ND WEATHER WING (MAC)
14 MAY 1981

Review and Approval Statement

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This technical report has been reviewed and is approved for publication.

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PUBLIC AFFAIRS OFFICER
HQ, 2nd WEATHER WING

FOR THE COMMANDER

MICHAEL G. OLIVIER, MAJOR, USAF
CHIEF, SCIENTIFIC SERVICES BRANCH
HQ, 2nd WEATHER WING

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meteorological instruments	weather	Greece	Athens
weather forecasting	seasonal variations	TFRN	Hellenikon
weather	seasons	forecast aids	climatic aids

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This publication contains information on the topography and location of meteorological equipment on station, climatic aids, circulation, and associated seasonal synoptic patterns for Hellenikon AB, Greece. It was written as an aid to the local forecast situation and as a source of information for the station.

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OL-C, 31st Wea Sq (MAC)

14 MAR 1981

I. LOCATION AND TOPOGRAPHY

Hellenikon AB Greece

International Index Number: 16716

Latitude: 37 Degrees, 54 Minutes North

Longitude: 23 Degrees, 44 Minutes East

Elevation: 90 Feet

Greece is a peninsula bordered on the west by the Ionian Sea and on the east by the Aegean Sea, both of which are part of the Mediterranean Sea. The terrain of this country is predominantly mountainous. These mountains are composed primarily of metamorphic rock and feature many steep slopes and precipices. The primary range is located in the western portion of the country; it's north-south orientation extends from the northern border to the Mediterranean Sea. Except for the Gulf of Corinth, the range is continuous and has peaks that extend to 8000 feet. The area to the north of Athens is dominated by an east-west mountain range with peaks that range from 2014 feet to 5069 feet. East of Athens, another range of mountains has peaks ranging from 2533 feet to 3638 feet.

Hellenikon AB is located 7 miles south of Athens, which is located on a small peninsula in southeast Greece. The western portion of this peninsula forms what is known as the Plains of Attica. This plain is bordered on the north and east by mountain ranges whose peaks are approximately 5000 feet and 3500 feet respectively and on the southwest by the Bay of Saronikos.

The north-south mountain range in western Greece, the east-west range north of Athens, and the north-south range east of Hellenikon act as barriers or dampers for systems moving into the greater Athens area. Typically, weather (clouds, convective activity) will stall on the windward side of these mountains. The weather that does spill over will generally be higher based and/or lessened intensity. The division between the two ranges north and east of Hellenikon and the downslope from that division to the sea contribute to a north-south pressure gradient that produces gusty surface winds from a north-northeast direction. Systems that move into Greece from the southwest will produce weather which is not impeded by any mountain range. Consequently, weather moving in from the south will have lower ceilings and visibilities, precipitation for longer periods with heavier intensities, and stronger surface winds than a comparable system moving into Greece from the northwest or northeast.

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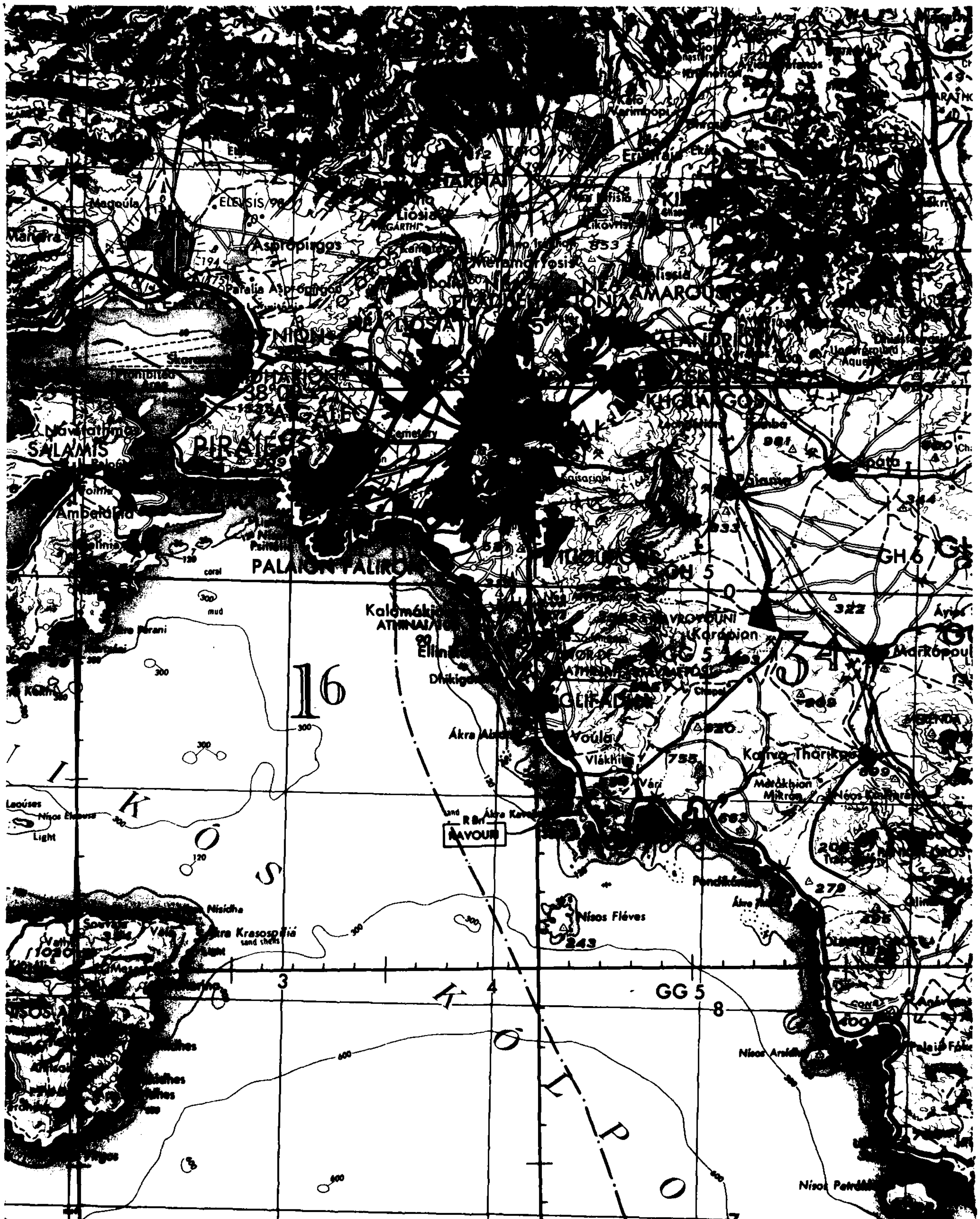
LOCAL TOPOGRAPHY



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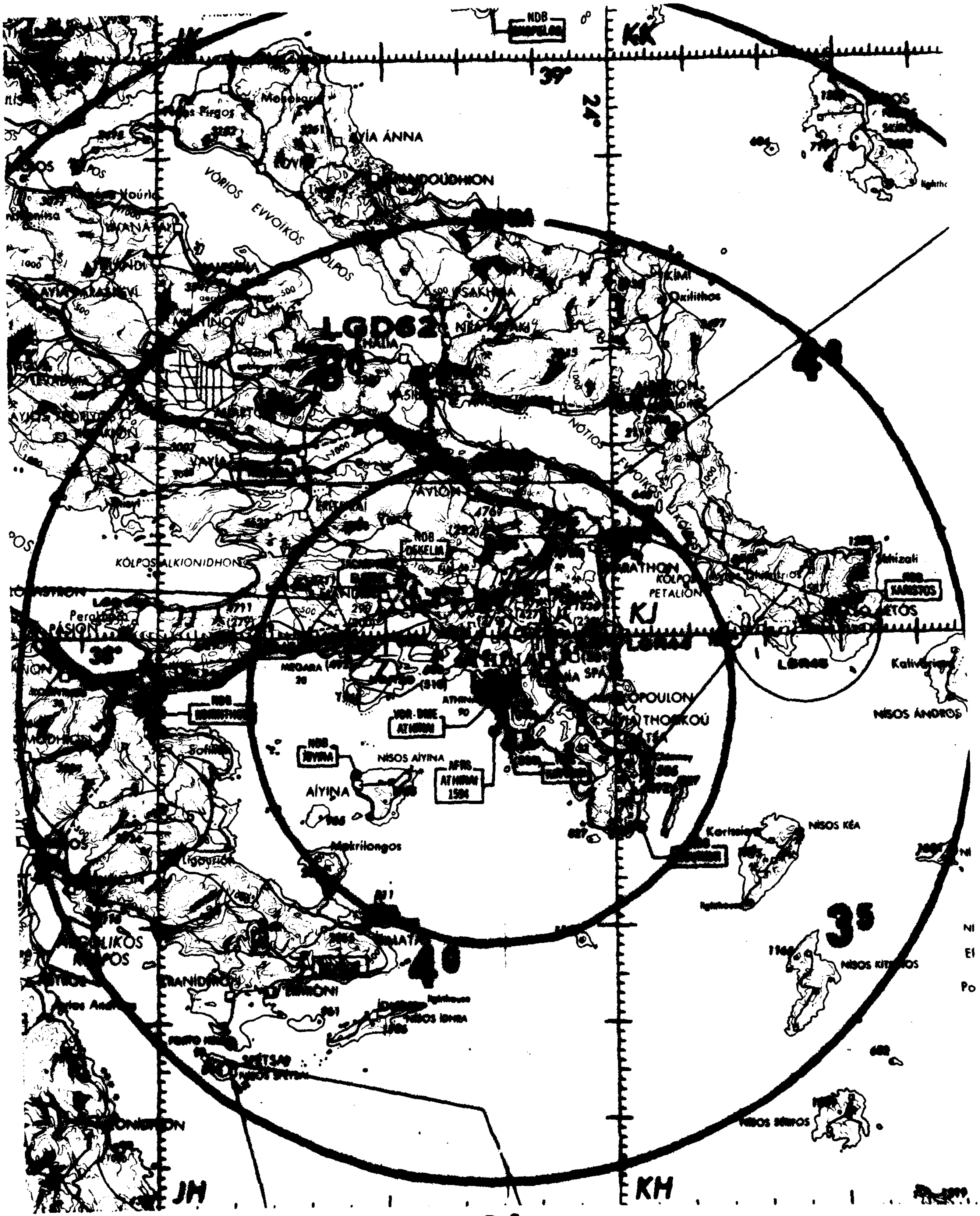
LOCAL TOPOGRAPHY



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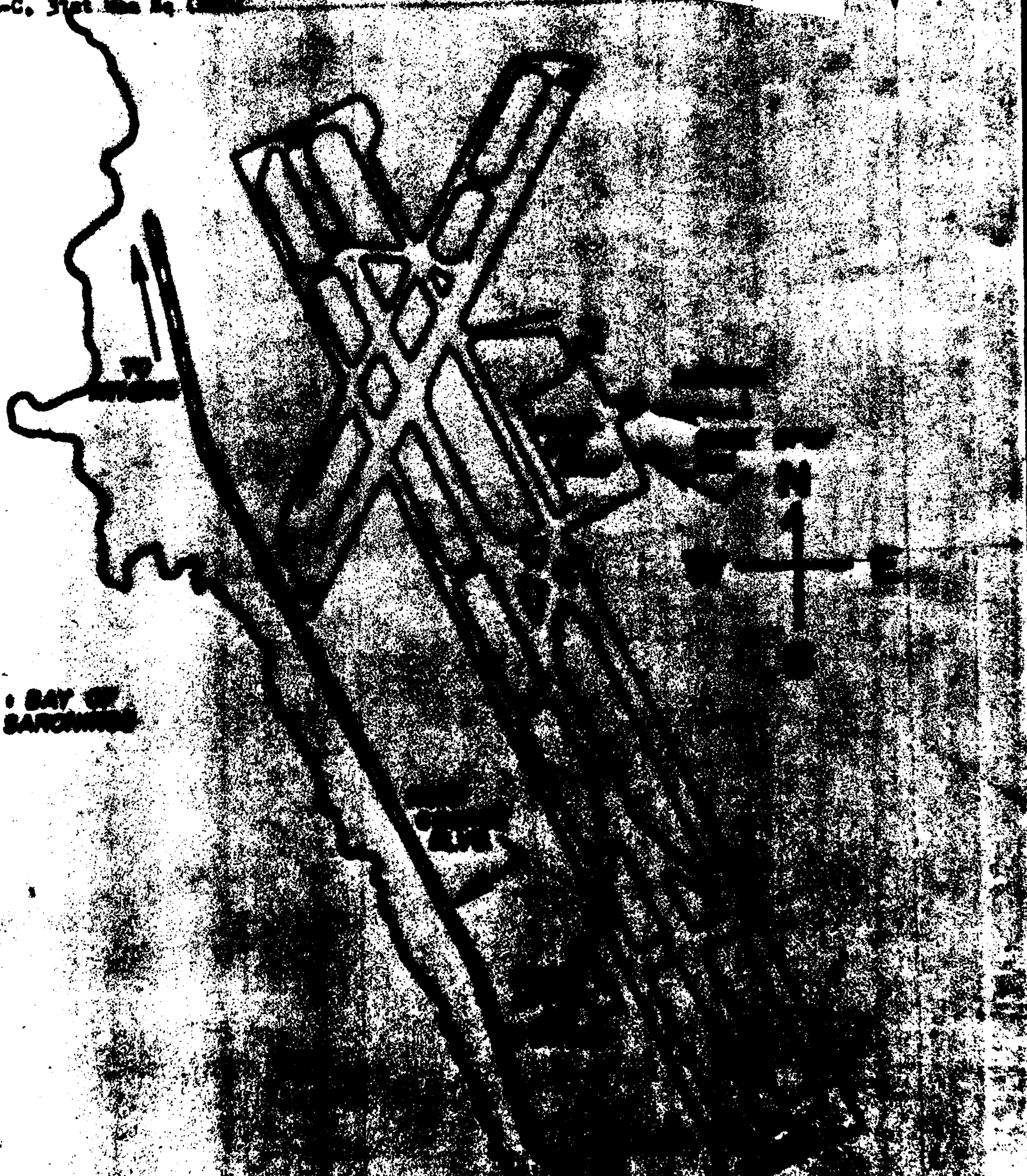

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meteorological equi
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sub-unit, Nationa

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II. CLIMATIC AIDS

Operationally Critical Weather Element	Threshold Value
Tornado/Waterspout	Observed or forecast to occur
Hail	Equal or greater than 3/4 inch in diameter
Surface Winds	Equal or greater than 25 knots
Precipitation	Falling at the rate of 1" per 12 hours or 1" per one hour
Ceiling/Visibility	Less than 1000 feet and/or 2 nautical miles
Thunderstorms/Lightning	Within 10 nautical miles and 3 nautical miles respectively
Low Level Wind Shear	Observed or forecast to occur
Probability of Lightning Condition	Equal or greater than an 80% probability

Because of the low incidence on occurance and lack of data, no graphical representation was attempted of tornadoes/waterspouts, low level wind shear, and high value probability of lightning conditions.

The graphs that will provide the forecaster with the greatest amount of assistance are the wind graph and the precipitation graph. Historically, these areas, especially when the two combine, have caused the greatest concern among the customers at Hellenikon AB.

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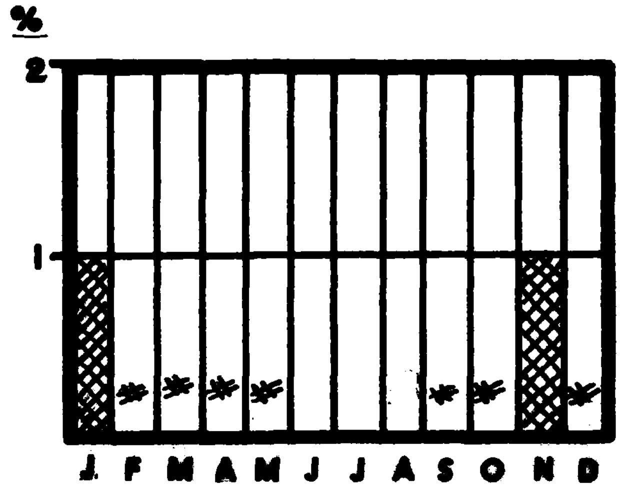
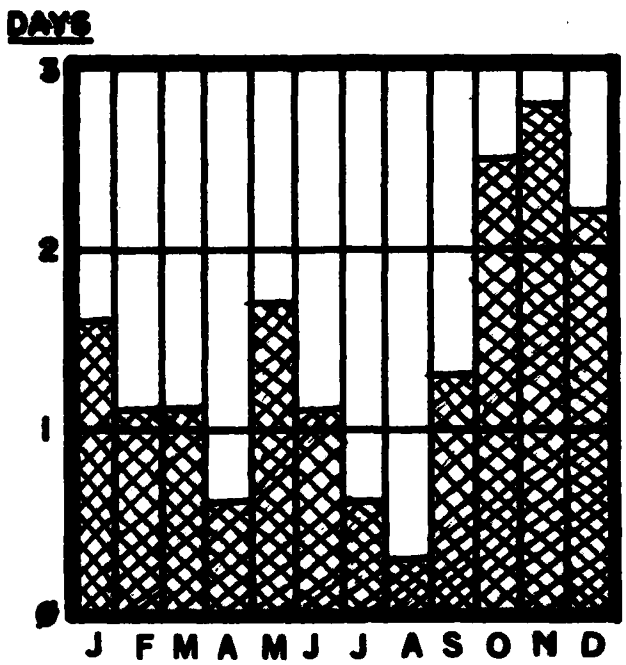
PERCENTAGE OF TIME
CEILING/VISIBILITY <1000/2
(*= <0.5%)
(p.o.r. 1964-71)



AVERAGE THUNDERSTORM DAYS
(p.o.r. 1961-76)



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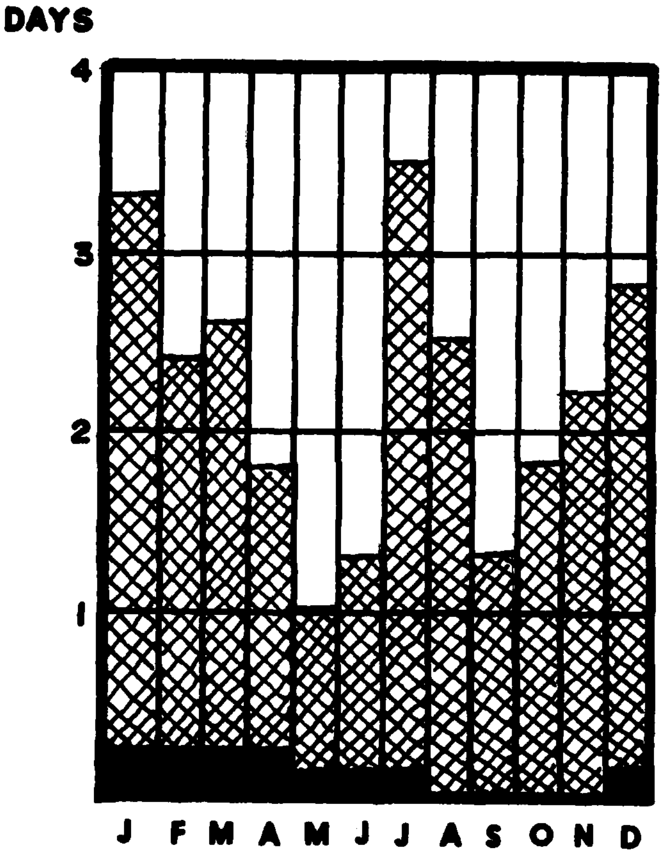
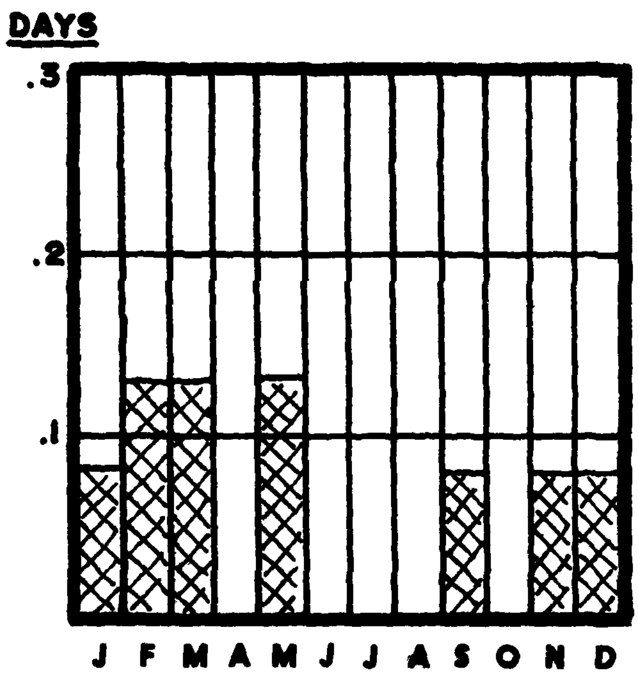
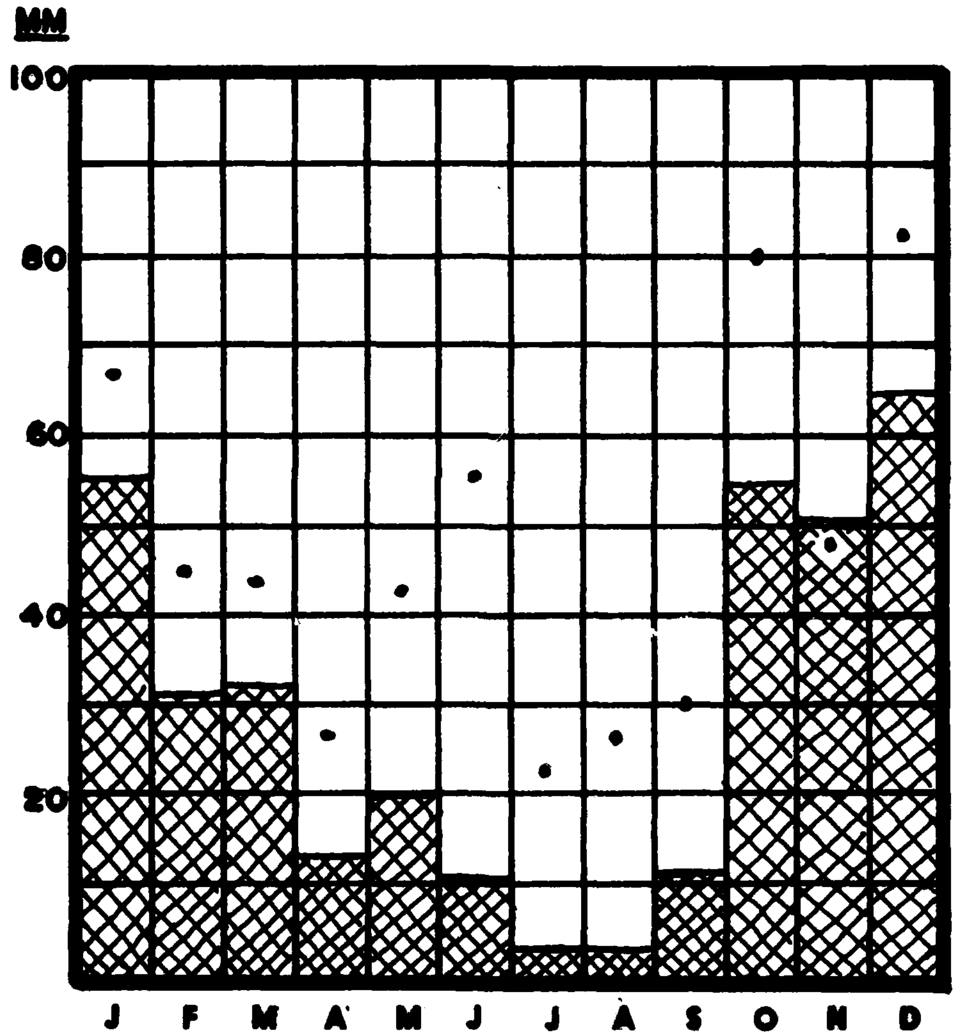


AVERAGE DAYS/MONTH WINDS AT
08L, 14L, and 20L exceeded
Beaufort 6 (22-27 knots)
Beaufort 8 (34-40 knots)
(p.o.r. 1946-78)

HAIL DAYS/MONTH
(p.o.r. 1961-76)



PRECIPITATION
● Maximum in 24 hours
Monthly Average
(p.o.r. 1961-76)



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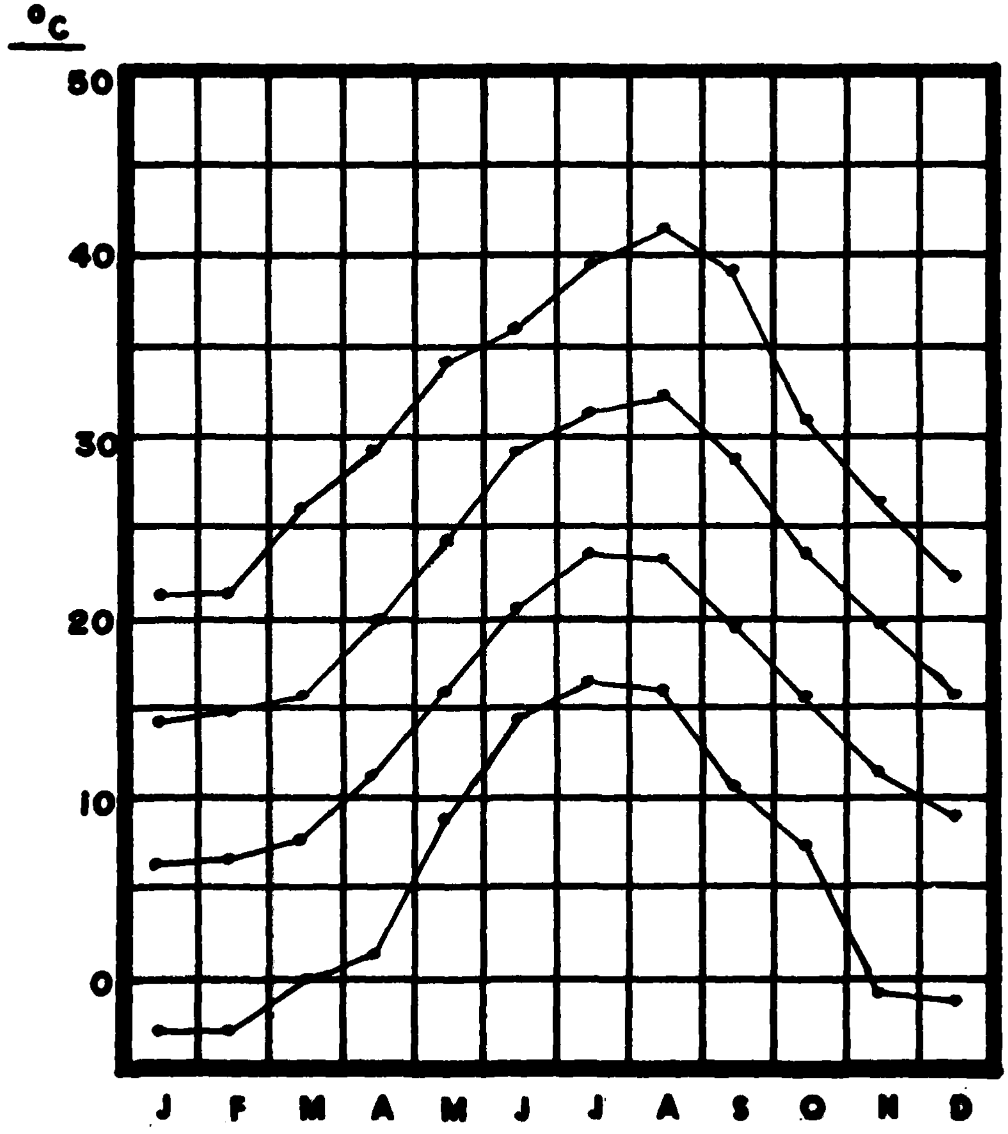
TEMPERATURES

Extreme Maximum
Average Maximum
Average Minimum
Extreme Minimum
(p.o.r. 1948-72)



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III. Approved Local Forecast Studies and Rules of Thumb

None

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IV. CIRCULATION AND ASSOCIATED SEASONAL SYNOPTIC PATTERNS AFFECTING HELLENIKON AB

PART A is a general account of the seasonal circulation and associated weather in the eastern Mediterranean.

PART B is a detailed description of seasonal weather.

PART A

GENERAL SUMMERTIME CIRCULATION PATTERNS AND ASSOCIATED WEATHER CONDITIONS

The circulation over the eastern Mediterranean is very strongly cyclonic, creating the prevailing meltemi wind of the Aegean Sea and the South Balkans. In spite of the cyclonic character of this circulation, the air is very dry and the sky is virtually cloudless. This strong flow is actually the western extension of the summer monsoon which originates in the Indian Ocean as a southerly current, passes northward across India to the plateau of Tibet where, as a result of the Himalaya mountains, the current is deflected to the west. Since the air is lifted to 20,000 feet as it flows across India and Tibet, rainfall is released from the airmass and the mixing ratio is reduced to a very low value. This monsoon current continues across Afghanistan, Iraq, and Turkey where any further northward movement is blocked by the east-west orientation of the Himalayan and Caucasus Ranges. At the western end of the Black Sea, the Dinaric mountains prevent any further westward motion due to their general north-south orientation. Hence the flow becomes northeast across the Aegean Sea and South Greece. This southerly flow continues across the Cyclades and the southern Peloponnesus becoming a northerly wind in that area, a northwest wind over Crete, and a west wind over Cyprus and the eastern Mediterranean. This circulation continues over Syria, curving southward over Arabia and the Persian Gulf into the Arabian Sea and the Indian Ocean where it becomes, once again, a southerly current over India.

During the period that this closed circulation affects the Mediterranean and Balkans, it is undergoing sharp cyclonic curvature. But, because of the extreme dryness of the cT air, there are no cloud patterns nor precipitation. On occasions, the prevailing meltemi becomes quite strong, producing winds in excess of 35 knots and persisting for several days. The "cut" in the mountain ranges northeast of Athens increases the pressure gradient under these circumstances because of a venturi effect. With respect to air operations, they cause rather strong turbulence below 8000 feet, and during periods of very strong meltemis, the turbulence can extend to 12,000 feet. Normally this turbulence does not

extend westward to the Araxos area nor northward to the Salonika area, but seems to limit itself to the area immediately surrounding the Attica Plain. The northeast wind usually reaches its maximum strength at about 5000 feet, above which it gradually backs to a northwesterly wind at 10,000 feet, and to a westerly wind at 15,000 feet.

Occasionally, the intrusion of the cold continental polar ridge from Russia across the Balkans increases the circulation across the Aegean Sea, which increases the strength of the meltemi. This summertime continental polar air also comes from the northeast with a vigorous push, but it contains more moisture and is often accompanied by cumulus cloud development. The onset of this intrusion can be best noted by carefully analysing the Balkan area for the movement of a weak cold front across Rumania, Bulgaria, and northern Greece. Usually the continental air behind these fronts will not reach southern Greece but will cause a pressure rise in the Salonika area which in turn tightens the gradient between Athens and Salonika to create a strong meltemi situation. The occurrence of thunderstorms in Macedonia at the outbreak of these weak polar fronts are not unusual, but the occurrence in southern Greece is very rare.

The circulation dominating the eastern Mediterranean is tied into the circulation of the western Mediterranean, which is under the influence of the sub-tropical Atlantic anticyclone (Azore High). It was mentioned above that the topographical effects of the Balkans deflected the Indian monsoonal flow into a strong cyclonic circulation southward over the Aegean Sea. Another factor, which may be a more effective cause for this deflection, can be found in the general circulation of the Azores High. During the summer, this anticyclone pushes northward into the Atlantic and also extends eastward across the western and central Mediterranean Sea. The circulation is normally such that the westerly flow comes across central Europe, curving southward in the vicinity of the Alps as a northwesterly wind across the Adriatic Sea, northerly across the Ionian Sea, northeasterly across Tripoli, easterly across North Africa, and southeasterly across the Canary and Madeira Islands. The region of maximum anticyclonic curvature is in the area of the Adriatic and Ionian Seas. Thus, western Greece is under the influence of prevailing anticyclonic circulation. An interesting anomaly exists in Greece during the summer months: eastern Greece, which is under the influence of cyclonic circulation, has prevailing clear skies and virtually no precipitation, while western Greece, which is dominated by anticyclonic flow, has cumulus development and occasional showers and thunderstorms. The primary difference is that the air mass transported by the Azored High is mT (moist and unstable), whereas the air in eastern Greece is primarily cT (unstable and dry).

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GENERAL WINTERTIME CIRCULATION PATTERNS AND ASSOCIATED WEATHER CONDITIONS

The winter circulation patterns over the Mediterranean do not appear to fit into a large scale circulation scheme as do the summer patterns. Necerless, large scale circulation patterns directly influence the pressure patterns found over the Mediterranean. The normal isobaric configuration in the winter over the Mediterranean is one of low pressure and attendant cyclonic circulation, resulting in wide-spread cloud patterns and abundant precipitation. The normal picture is that of a cyclonic vortex over the Tyrrhenian Sea and another vortex over the far eastern Mediterranean seperated by a pronounced ridge over the Balkans. This ridge is actually part of the blocking Siberian anticyclone and is an effective block to the eastward migration of cyclones and, also influences the weather and climatology of Greece.

It might be well to investigate the genesis of these two Mediterranean cyclones in order to be better able to forecast the movement and development of the vortices. Prior to the development of the deep vortex over the Tyrrhenian Sea, there is normally an arma of weak low pressure, or at least a potential cyclone, in the Gulf of Genoa. The Appenine Mountains of Italy are oriented northwest-southeast and intercept the Alps at a right angle in northern Italy. This configuration forms a pocket around the Ligurian Sea and the Gulf of Genoa such that the westerly winds advancing across the Mediterranean Sea are deflected northwest across Italy by the Appenines and, in coming up against the barrier of the Alps, are again deflected to the southwest. There will be westerly winds across Sardinia and Corsica becoming southeasterly across Italy and northeasterly along the Alps. The flow returns to the Mediterranean in the Nice-Marseille area and once again becomes westerly over Corsica and Sardinia. Examination of a topographical map of this area will clearly show the configuration which leads support to the cyclonic development in the Gulf of Genoa. In order for this vortex to develop, it is necessary to have an injection of cold air into the Mediterranean west of Marseille or an increase of northerly momentum which will bring the necessary energy into the Mediterranean on the west side of this embryonic cyclone. Whether the cause of the cyclogenesis is the transport of cold air or momentum and energy is purely academic, since both occur simultaneously. With the advection of the cold air into the western Mediterranean, a rapid cyclogenesis occurs in the Gulf of Genoa.

The ridge over the Balkans appears to strengthen during the intensification of the cyclone in the Gulf of Genoa and acts as a tremendous block to the eastward movement of the newly formed cyclone. Consequently, the cyclone moves southeastward into the Tyrrhenian Sea and tends to stagnate near Sicily. By this time, the strong influx of energy into the western Mediterranean has ceased and the westerlies are again streaming across central Europe and northward around the Siberian High, creating a cut-off low in this region. The main thing to watch for in order to forecast the movemet of the vortex is the advection of warm air at 500mbs across central Spain and into the western Mediterranean. After the onset of this warm advection, the vortex will stert moving eastward with a filling tendency. Its normal track is southeast across or just to the north of Crete and then eastward to Cyprus or northward across Turkey.

The factor which controls whether this cyclone continues eastward to Cyprus or northeastward across Turkey appears to be the strength of the Siberian High. During periods when this anti-cyclone is strong, a strong east to northeast pressure gradient prevails across the Black Sea and Turkey preventing the northward movement of all but the most intense cyclones. During periods of weakening Siberian High activity, the cyclones progress north-easterly from Crete to Turkey. Each individual case must be studied on the basis of the relative strength of the cyclonic circulation and the Siberian High. Another factor which may aid the forecasting of movement of this low from Crete is the orientation of the 500mb jet-stream. If the jet's southwesterly flow on the east side of the 500mb wave is west of Cyprus, then cyclones in the vicinity of Crete will almost always move north-eastward across Turkey in lieu of a more eastward track towards Cyprus.

Storms that migrate from Italy across the Ionian and southern Aegean Seas undergo a regeneration or deeping. As the cyclones move slowly across the Ionian Sea, the blocking action of the Dinarics continue to maintain considerable strength, and strong northeast winds will persist along the east coast of Greece long after the axis of the ridge has passed to the east and the isobars indicate that the wind should be southeast. Against such resistance, the cyclone crosses the Ionian Sea with a filling tendency. However, as the cyclone passes south of the Peloponnesus and the axis of the trough passes east of Athens, the winds along the coast of Greece back from the northeast to the north and finally to the northwest. As these cyclones progress east of 25 degrees East. the circulation of the Balkan ridge is instrumental in causing a strong flow of cold air from Rumania, Hungary, and Bulgaria down across Greece and into the back side of the cyclone. This influx of cold air into the cyclone causes an intense cyclogenesis bringing about the creation of a major storm. This particualr circulation causes the most severe cold weather experienced in Greece.

In the winter, it is not unusual to observe two major cyclonic circulations in the Mediterranean simultaneously: one in the eastern Mediterranean deepening, and one in the Gulf of Genoa undergoing cyclogenesis. At such times, the 500mb chart shows a large cyclonic circulation over the entire Mediterranean Sea with the jet coming into the far western Mediterranean as a strong northeast current current, across North Africa as a westerly current, and a strong southwesterly jet across the eastern Mediterranean. With such a circulation pattern, cold air persists over the entire Mediterranean with the centers of the coldest air over Sardinia and the southern Aegean Sea. At 500mb, there is usually a slight ridge seperating the two vortices and supplementing the Balkan ridge.

When the jet stream is displaced northward across the central Mediterranean, the storm tracks are slightly more complicated in nature. This type will generally move directly eastward across the Ionian Sea with a filling tendency. However, instead of moving freely across the open sea south of Greece, they tend to decelerate on approaching the mountain ranges of western Greece. As a rule, the air masses approaching Greece across the Mediterranean from the west are not as cold and dense as those which comprise the Balkan ridge. Hence, the cold front marking the advancing edge of the air mass will override the Balkan ridge as an upper cold front. However, as a result of the cold air advection aloft, the lapse rate is steepened and the entire circulation becomes more unstable. The result of this instability is a vigorous cyclonic circulation forming as the upper cold front advances to the Aegean Sea from Greece. Almost always, the resulting cyclone in the Aegean Sea has a lower sea level pressure and a stronger circulation than the low pressure disturbance had while in the Ionian Sea. Due to the more northerly extension of the jet stream across the Mediterranean, these regenerated cyclones normally move northeastward into the Black Sea. This type of Aegean cyclone is usually instrumental in causing considerable flooding in Macedonia and Thessali, whereas the type of cyclone which causes the most flooding in Attica is the slow moving cyclone which passes through the straits between Crete and the Peloponnesus and then sharply recurving northeastward into the Aegean Sea passing just southeast of Athens.

These maritime cold fronts which approch Greece from the west do not cause a significant temperature decrease with their passage, since, as indicated above, they usually pass as an upper cold front. However, they do induce a secondary circulation in the AEgean Sea which causes the winds over Greece to back from the northeast, to the north, and eventually to the northwest as the newly formed cyclone moves into Turkey. This causes the same conditions as described earlier when the cold continental air is drawn southward over the Balkans, and in some cases, all of Greece. The passage of this second or continental type cold front is not marked by any appreciable amount of precipitation but by strong northerly winds and wide-spread stratus type clouds over the entire eastern coast of Greece.

A third, less frequent type of cyclone pattern in the Mediterranean, is the migration of cyclones into North Africa then eastward across Libya and Egypt. The mechanism responsible for this pattern is a continuous strong flow of northerly winds aloft across the western Mediterranean (500mb wave of considerable amplitude across Spain and Morocco) which virtually drives the cyclones into North Africa before their recurvature to the east. As these cyclones progress eastward across North Africa or the southern extremities of the Mediterranean, the winds to their east may be derived from the desert hundreds of miles to the south and southeast. They are abnormally hot and dry and will often carry dust and fine sand. These desert winds (siroccos) may blow as far as the central or the northern sections of the Mediterranean. In crossing the sea, they are cooled and pick up a great deal of moisture. When this air reaches the coasts of Italy and Greece, they are warm, damp, and depressing, and they contain heavy rains which may be heavy in dust particles from the Sahara. While these "red rains" are observed as far north as Athens on occasionm, the North African cyclone tracks generally produce only middle and high cloudiness with occasional rain in South Greece. Once the trough passes 25 degrees East, a fairly strong northerly circulation sets in across Greece which may or may not induce the flow of cold continental air from the Balkans into southern Greece.

A fourth migratory cyclone pattern is related to a jet stream flow oriented from Ireland southeastward across France and into the Mediterranean. Associated with this flow are cyclone families which occur at regular intervals from the North Atlantic across Europe and directly into the Aegean Sea with a filling tendency while crossing the Ionian Sea.

It should be recognized that there are many variations and complications to the four basic types of winter storms described. Each particular storm system must be evaluated in terms of its relationship with the jet stream and its proximity to either cold or warm air sources. In short, the four basic types of winter storms are as follows:

TYPE A It will form in the Gulf of Genoa, become a cold vortex or "cut-off" low, undergo filling across the Ionian Sea, deepen in the Aegean Sea, and move eastward across Turkey and/or the eastern Mediterranean.

TYPE B It will form in the Gulf of Genoa, move slowly across the northern Ionian Sea with a filling tendency, ride aloft across Greece as an upper cold front, induce very active cyclogenesis in the Aegean Sea, and move northeastward into the Black Sea.

TYPE C It will form in the far western Mediterranean, drive into North Africa, move eastward across Libya and Egypt, cause severe sand storms in North Africa andoccasionally cause "red rain" and associated cloudiness in South Greece.

TYPE D Cyclones families which move across the North Atlantic, southern England, southwest Europe, and into the Mediterranean. In this type, the jet stream enters the Mediterranean from the northwest, which is in contrast with the type A above where the jet enters from the mortheast. The northeast entry of the jet in type A induces cyclogensis in the western Mediterranean, while the type D usually induces cyclogenesis in the Aegean Sea.

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PART B

For all practical purposes, the climate of Hellenikon AB can be divided into two seasons: Winter--November through March and summer--May through September. The months of April and October are considered transition months and weather typical of either season can be expected.

SUMMER

The summer season is almost void of clouds and precipitation. Rainfall which does accur comes only from thunderstorms which average two per month. Mean cloud cover is but 1/8 coverage, and it is based high, usually above 3000 feet. The only restriction to visibility is haze caused by light winds and intensifying high pressure. Visibility will sometimes be as low as 3 miles under these conditioms, but improvement to 5 miles or better can be expected by noon.

MEDITERRANEAN HIGH

Source Region: This system forms in the east-central Mediterranean, east of 10 degrees East longitude.

Structure: The pressure gradient may be so weak that it is difficult to analyze a closed center. The flow aloft over this area may show a closed high, ridge, or a weak diffused pattern.

Associated Weather: Clear and warm weather is associated with this system and will persist up to three weeks.

CONTINENTAL HIGH

Source Region: Within the area of Yugoslavia, Czechoslovakia, Lower Poland, Romania, and Bulgaria.

Structure: High pressure with a central pressure above 1030mb. A wedge of this system will be oriented towards Greece. This system will bring in cold, moist cP air from Russia.

Associated Weather: The majority of thunderstorms observed at Hellenikon are associated with a surge of this high pressure system.and a progression of an identifiable long wave which moves directly over Athens. Either one of these conditions does not seem sufficient to produce thunderstorms or showers in the area, however isolated thunderstorms will develop in the mountains of North Greece. Thunderstorms at Hellenikon AB are extremely rare between June 15 and September 15. Other than the above, the only effects of this continental system are northeast surface winds of 15 to 20 knots and cooler temperatures.

MONSOON EFFECT

Source Region and Structure: Astrong cyclonic flow originates in the Indian Ocean as a southerly current, passes northward over India and Tibet, across the Tibetan Plateau, and curves westward. Orographic lifting and abundant rainfall have reduced this current to an extremely dry airmass as it continues across Iran, Turkey, and the Black Sea. Further north and west movement is blocked by the Caucasus, Balkans, and Dinaric Mountains. Consequently, the air flow turns southward over the Aegean Sea and South Greece. The flow then turns towards Crete and becomes a westerly wind by the time it nears the eastern Mediterranean.

Associated Weather: During its northeast flow over the Aegean Sea, the circulation is cyclonic, but due to its dryness, no attendant cloud pattern or precipitation is present. This dry wind is called a "Meltemi" or Estian. On occasion it will persist for several dayswith speeds ranging from 25 to 35 knots. Associated with these strong winds will be moderate to severe turbulence in the lower layers and some visibility reductions in dust.

WINTER

It is during the winter that Hellenikon encounters the majority of its inclemet weather. Forecasting this weather resolves itself into the detecting and moving one of five distinct synoptic conditions and/or systems. Most cloudiness and precipitation are associated with either Mediterranean Lows or Continental Highs. Most fair weather occurs with either the long wave over Spain, ridges of high pressure, or weak pressure gradients. In studying the evolution adn motion of the following Mediterranean depressions, it is important to become familiar with the average cyclone tracks and their frequency in the Mediterranean.

MEDITERRANEAN LOWS

From the Gulf of Genoa extending to the Sahara Desert is the primary source region for low pressure cells that have the most influence on the weather at Hellenikon AB. In the Gulf of Genoa we have an area of cyclogenesis and generally a semi-permanent small low which is undoubtedly induced from the air flow around the Alps. This low will not move out of the Gulf but must combine with some other system in order to intensify and migrate. Two typical examples of this phenomena are observed. The first is when a low moves across France into the region. The second is the penetration of a front into the Gulf from the Rhone Valley. Within 12 to 18 hours after either of these developments, the low will deepen quite rapidly and move to a position between the coast of Italy and the Islands of Corsica, Sardinia, and Sicily.

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Another favorable source region is the Sahara Desert. Many of these lows move in from the Atlantic, through the Sahara, and northward into the Mediterranean. This area is favorable for cyclogenesis in the late winter and spring.

Under all conditions when lows form in the area between the Gulf of Genoa and the Sahara Desert, the long wave was progressive and the surface system was associated with a trough at 700mb.

TYRRHENIAN SEA LOW

When a low pressure system enters the western part of the Mediterranean, becomes well developed and has closed contours through 500mbs, is stacked vertically in the atmosphere, it will remain relatively stationary in an area west of the Italian peninsula.

Associated Weather and Forecast Techniques: While the major system remains in this area, Hellenikon encounters almost daily showers and squalls from migrating troughs that leave the primary cell and advance eastward. These troughs depart at 18 to 24 hour intervals and are not usually detected until they arrive in the Ionian Sea. Once spotted, they should be moved eastward at a speed equal to the 700mb component that is normal to its orientation. The station at Araxos, 113 miles west of Hellenikon, is of some help in determining the approach of these systems but doesn't reflect the intensity of the system because of the orographic features along the western edge of Greece. When the trough is within 2 to 5 hours of Hellenikon, altocumulus and altostratus clouds will appear. With the passage of the trough, rain or showers will persist for 30 minutes to 2 hours, followed by rapid clearing. The wind will seldom shift with these troughs. Ocassionally, strong pre-thunderstorm downrushes are experienced and they give warning of their approach by a sharp rise in pressure (1½ to 2½mb) and the sighting of a well defined roll cloud approaching the airport from Saronikos Bay (20 to 30 minutes leadtime). The occurrence of frontal, trough, or line thunderstorms is not very common, but when they can be forecast, a minimum ceiling of 1000 feet and 3 miles visibility can be expected for a period not to exceed 30 minutes. The mean expectancy of thunderstorms during the period is 2 per month. The movement of fronts aloft through Athens, specifically cold fronts, give all the same indications as outlined for troughs and will produce the same weather. The only noticable difference is a drop in temperature at the 700mb following passage and, after 18 to 24 hours, the cool air sinks to the surface without creating any weather.

CYPRUS LOW

Depressions that move eastward through the Mediterranean and south of "Greece will become semi-stationary in the vicinity of Cyprus if a high pressure system exists over Arabia and extends to the Caspian Sea. Lows that become stationary in this area tend to deepen and show closed contours through 500mb.

Associated Weather: This system has very little affect on the Hellenikon AB, other than inducing northeast surface winds.

MIGRATORY LOWS

Lows which are classified as migratory are those that follow one of the general paths outlined earlier. The axis of these systems are at an angle sloping upward to the west. The method of forecasting the direction of movement of these systems follow accepted rules for steering surface systems from upper level flow. Variations, however, should be expected due to topographical effects of the land mass protuberances in the Mediterranean.

PATH A

This path varies in its trajectory across Greece from the central region to the northern border. However, there is little difference in the associated weather except that the chance of precipitation becomes more probable with the low center closer to Athens. As this low moves into the Adriatic Sea and proceeds eastward across Greece, the weather affecting Athens is similar to that of the Tyrrhenian Sea low. If this system moves into the Aegean, it will develop and cause either strong sortheast surface winds or northwest winds, depending on how far north of Athens the low passes. Due to local terrain effects, a deep low in the Aegean causes only scattered fracto-cumulus. Storms may follow this path during any part of the winter.

PATH B

When a western Mediterranean low moves down and passes to the south of Greece, one can expect a prolonged period of low cloudiness and precipitation. The ideal situation for movement of a low in this direction is the existence of a high pressure cell situated over North Central Europe, preferably one which is oblong in shape and extending from England to Russia. A slow progression of the long wave is conducive towards maintaining the intensity of the cyclones and also helps establish its direction of movement. A retrogression of the long wave will cause filling of the low and rapid eastward movement causing little activity at Hellenikon. The type of weather encountered

at Athens with the eastward movement of a low in the Mediterranean which retains its intensity is that which is usually experienced with a warm front. However, it is difficult to analyze any surface map and orient a warm front primarily because it does not seem to show continuity. A true synoptic warm front at the surface may be indicated on one map and then, six hours later, the temperature gradient may be reversed. The same lack of continuity of movement is indicated by aircraft flying between Athen and Tripoli with respect to upper warm fronts. However, when the center of the low reaches a position southwest of Athens over the water and has reached an intensity sufficient to be detected by land stations, the weather that should be anticipated at Hellenikon is light drizzle and rain with visibility prevailing at 5 to 6 miles. Kavouri beacon, 5 miles south of the airdrome, will usually have clouds lower than 1200 feet. This fact is reported and confirmed by many pilots. One theory proposed is that with a low to the south of Athens, the winds in the lower levels are from the east. With reference to the topographical map, the 3000 foot range east of the airport would cause some adiabatic heating and consequently cloud bases should be higher over the airport than at Kabouri beacon, which is more open and unprotected. The surface wind will be predominately from the north-northeast, only rarely shifting to the east or southeast. This north-northeast wind is the dominating feature of bad weather at Hellenikon and will, at times, blow 60 degrees across the isobars. Two reasons are at first apparent for this consistent wind. The first is the venturi effect created by the mountain valley between two fairly high ranges. Second, is the rugged, 3000 foot range located 3 miles east of the airport which causes an exceptional amount of friction and practically overcomes the coreolis parameter in the gradient wind equation. Therefore, the wind is forced to blow inward across the isobars at a great angle. The weather with a storm moving along this path will persist for approximately 24 hours or until the storm passes the 135 degree radial from Athens. This storm path is the most common track during the middle months of winter.

PATH C

When a low follows the shoreline of North Africa, the effects on Hellenikon is cloudiness based at 1500 feet and no precipitation. Occasionally, this circulation is intense enough to create severe dust storms in North Africa and, since the hot desert air picks up moisture as it slows across the Mediterranean, the southern portion of Greece. Visibilities that can be expected are as low as 2 miles in "red rain" and dust for a period lasting up to 18 hours. This path is most active during the latter part of winter.

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MIGRATORY LOWS THAT SPLIT OVER GREECE

There is a tendency for lows that move ever Greece to split into two cells: one cell over the Ionian Sea and the other over the Aegean Sea. This seperation can be described mathematically by applying a topographical function to the gradient wind equation. Due to the cold layer of air over land in contrast to the warmer air over the water, the following effects can be expected to take place: increasing or decreasing of the pressure gradient along the peninsula, anticyclonic curving of the isobars along the peninsula, and the formation of a col over Greece.

CONTINENTAL HIGHS

The second major type system that gives Hellenikon inclement weather is a strong high pressure cell that forms over North Central Europe in the lowland countries and brings cP air from Russia into Greece.

SEMI-STATIONARY HIGHS

When a high pressuren cell with a minimum pressure of 1030mb becomes stationary in North Central Europe, Hellenikon receives considerable cloudiness, strong cold winds, and intermittent rain or snow.

Structure: The indicators of this system begin with a high over North Central Europe with a wedge that points towards the southeast. Within this wedge, and 24 hours prior to deteriorating weather at Hellenikon, a strong rise in the three hour pressure change can be noted. Simulaaneously, the movement of the long wave just east of Hellenikon will become stationary. In this position it is desireable that northerly flow at the upper levels be directly over the high at the surface. The high will move into the area of Rumania or Poland and become semi-stationary. Located somewhere to the south of Hellenikon should be a small surface low.

Associated Weather and Forecasting Techniques: From this system Hellenikon gets most of its true cold front passages. The weather to be expected with a surge of this high pressure consist of strong northeast winds of at least 30 knots. The cold front, oriented east-west, will move south and pass Hellenikon with all the typical characteristics except that there will be no wind shift, the weather will not clear, and thunderstorms are rare. In and behind the frontal zone conditions are ceilings of 2000 feet and light rain. It is from this system that Hellenikon receives its only snow once or twice a year. Temperatures expected are contingent upon the air mass but, as a general rule, can be expected to hover near freezing. It is not the temperature so much as the strong north winds that make this system so undesireabl**e**. As long as the

upper flow remains from a northeasterly quadrant over Athens, this cloudy, cold, windy, and showery condition will persist, even though the high at the surface may weaken and move several hundred miles. After the initial surge, the bases of the clouds will become higher on succeding days. Following the primary cold front, there appears to to be a secondary system that passes Hellenikon at intervals of 18 to 24 hours. This secondary system forms in the lower Balkans and Aegean Sea and is sometimes not detected on the surface analysis until they pass Athens. Often these secondary pushes deliver more precipitation than the primary system. Forecasting these secondary surges is difficult unless they are detected while they are still in the Balkans. However, they should be expected because they usually exist. These semi-permanent highs will remain in the area for periods of 2 to 3 weeks.

MIGRATORY HIGHS

The migratory highs that move into Greece from North Central Europe will produce the same weather as the semi-stationary system with the exception that the duration of the weather is only 1 to 2 days. By the time the center of the cell reaches Turkey, it is no longer an influence on Hellenikon weather.

AZORES RIDGE

Structure: A ridge or wedge from the Azores will extend into the western Mediterranean, or a closed high pressure cell will be in the vicinity of France or Spain.

Associated Weather: Fair weather prevails with this system. If the system is sufficiently strong, it will be independent of the upper air flow directly over Athens.

UPPER RIDGE OVER GREECE

Structure: A long narrow ridge aloft that is quasi-vertically aligned from 700mb to 300mb with Greece near the apex of the ridge (apex to the north). This structure implies the existence of two waves aloft: one situated over the eastern Mediterranean and the other over the western Mediterranean. Associated with this system on the surface is a weak high pressure system.

Associated Weather: Hazy skies persist throughout the period with visibilities restricted to 3 to 5 miles during the morning. Improvements will be after 0900Z. The haze condition extends well into the upper levels. The winds aloft will be light and variable. This system moves eastward, but occasionally the motion is so slow that Hellenikon will be under the influence of this ridge for several days.

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LONG WAVE OVER SPAIN

Structure: A long wave at the 500mb level with considerable amplitude and remaining stationary in the vicinity of the east coast of Spain.

Associated Weather: With this system the air flow over Hellenikon is from the southwest and has considerable trajectory across Africa making it warm and stable. Under this system, small migratory systems will move through the Mediterranean with little or no affect on Hellenikon.

WEAK PRESSURE GRADIENT AROUND HELLENIKON

Structure: A weak pressure gradient at the surface with isobar spacing in the eastern Mediterranean of 2mb per 150 miles or greater.

Associated Weather: Fair and balmy Mediterranean type weather is the rule with this system.

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SUMMER CIRCULATION PATTERNS AND ASSOCIATED WEATHER

Area 1

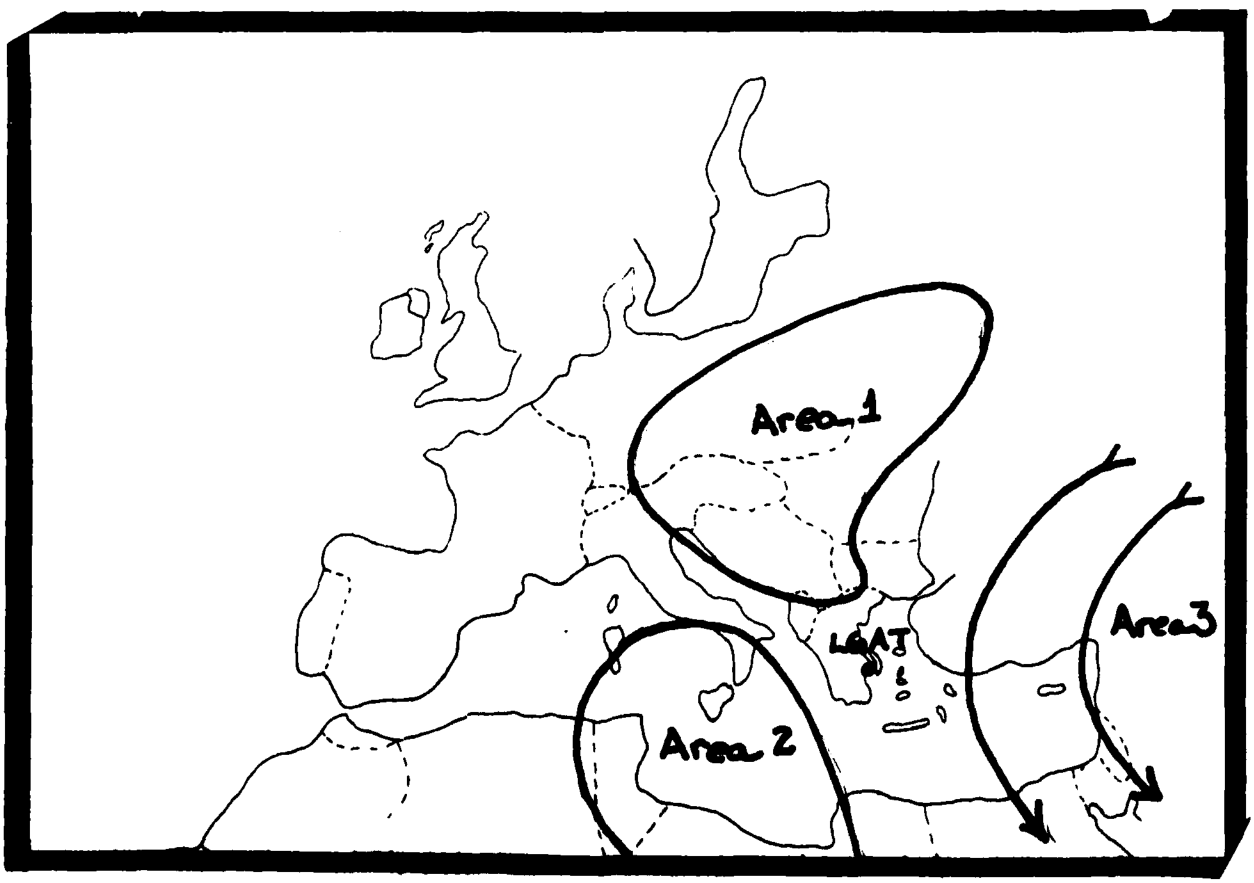
Continental high pressure over East Central Europe.
Showers and thunderstorms in North Greece, fair skies and northeast surface winds at Hellenikon.

Area 2

Mediterranean high dominates the central Mediterranean.
Showers and occasional thunderstorms in West Greece, fair skies at Hellenikon.

Area 3

Monsoonal flow around the Asiatic low.
Strong north-northeast surface winds (Meltemi). Turbulence in the lower layers.
Fair skies and warm temperatures.



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WINTER SEMI-STATIONARY SYSTEMS

Area 1

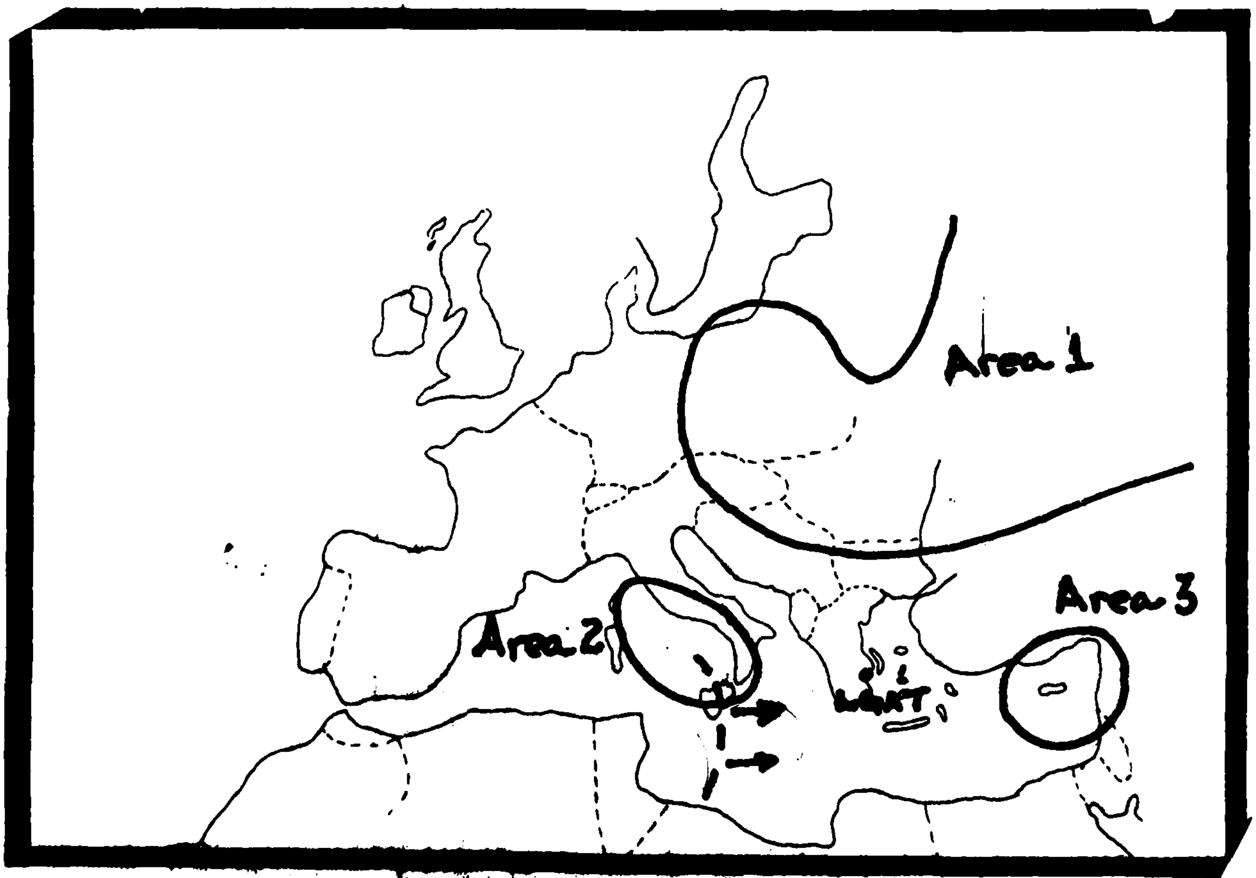
cP air source. True cold fronts with strong north-northeast surface winds, rain or snow showers.

Area 2

Tyrrhenian Sea low. Troughs, acting like cold fronts will spawn at 18 to 24 hour intervals. Showers and/or thunderstorms are expected.

Area 3

Cyprus low. Little affect other than northeast surface winds.



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WINTER CYCLONIC AND ANTICYCLONIC SOURCE REGIONS

Area 1

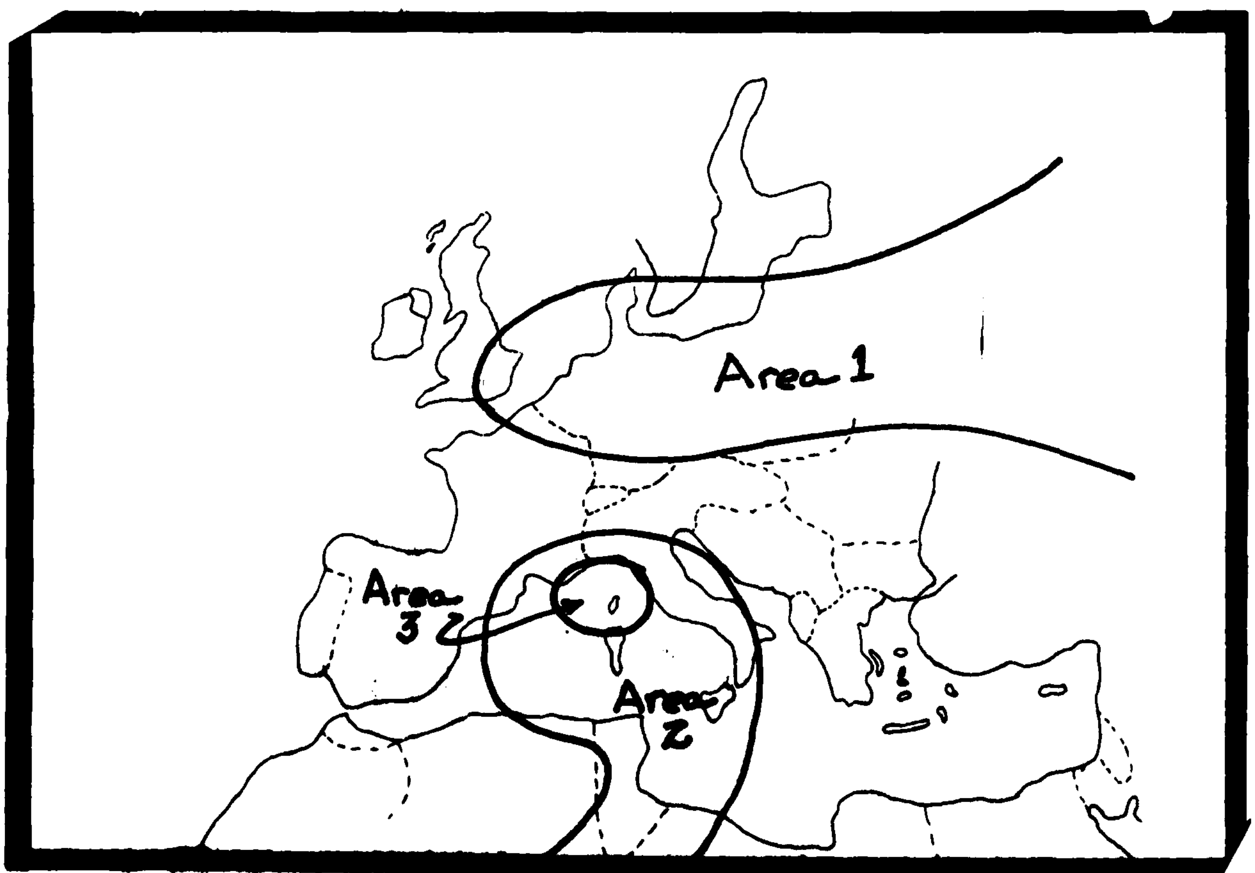
Source for cP air in Greece. Cloudy skies and occasional rain or snow squalls. Strong gusty surface winds and near freezing temperatures.

Area 2

Storms entering the Mediterranean Sea undergo cyclogenensis in this area if surface system combines with appropriate upper level system.

Area 3

Orographically induced area of low pressure. System must unite with upper level system to affect Athens area.



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WINTER CYCLONE TRACKS AND ASSOCIATED WEATHER AT HELLENIKON

Path A

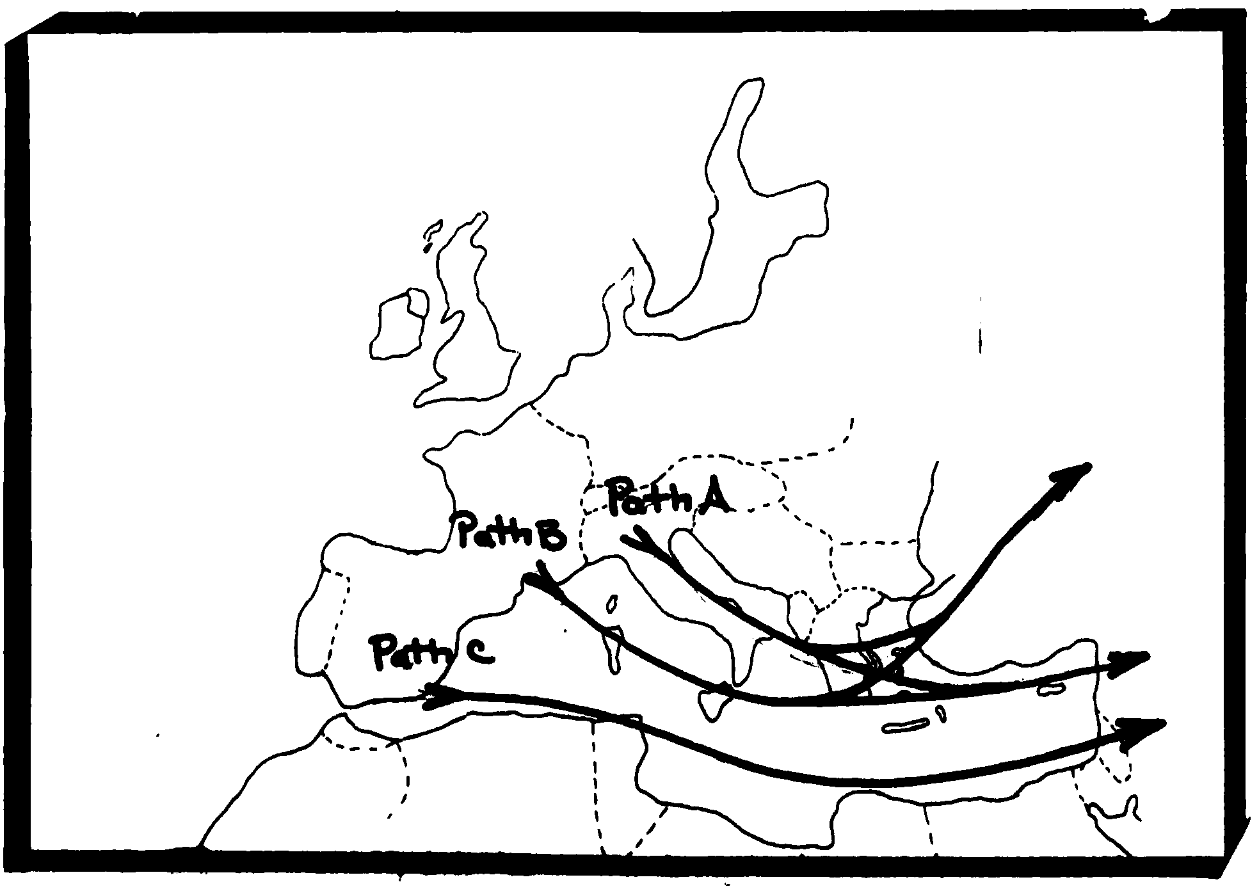
The movement of the low through Greece is dependent on the steering currents. The probability of showers increase if the center of the storm passes near Athens. Watch for development once storm is in the Aegean Sea. Gusty surface winds that will become stronger once low is in the Aegean Sea.

Path B

Low cloudiness, rain, showers, and gusty surface winds as the low moves through Greece. Development is likely once the low passes into the Aegean Sea. Watch for secondary surges of cold air behind surface cold front.

Path C

Cloudy skies with no precipitation. Dust and haze are visibility restrictions and occasional "red rain" in areas south of Athens.



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WINTER SITUATIONS THAT PRODUCE FAIR WEATHER AT HELLENIKON

Area 1

High pressure ridge or closed cell at the surface

Area 2

The surface pressure gradient is weak.

Area 3

500mb trough is over East Spain and has considerable amplitude.